

Direct Link Networks and Error Correction Codes

Assigned reading: Peterson and Davie: Chapter 2.1 – 2.4. All problems carry equal weight.

1. Noisy Channel Data Rates

The decibel is a measure of the ratio between two signal levels: $N_{db} = 10 \log_{10} (P_2/P_1)$, where N_{db} = the number of decibels, P_1 = the input power level and P_2 = the output power level.

- a. A telephone line is known to have a loss of 20db. The input signal power is measured as 0.50 watt and the output noise is measured as 8 μ watt. Using this information, calculate the output signal-to-noise ratio in dB.
- b. What is the capacity of this phone line with a frequency range of 100 Hz – 1000 Hz?
- c. If the attenuation rate of this phone line is 2db/km, and the minimum output signal is 0.00025 watt, given the input signal from part a), how long can the phone line be before requiring a repeater?

2. Encoding, Channel Capacity and Modulation

- a. Show the NRZ, Manchester, NRZI and 4B/5B encoding signals (the resulting NRZI signal for 4B/5B), using a diagram similar to that in Figure 2.10, p. 82, P&D, for the data bit sequence 10111 10100 11011 10110. To be definite, suppose the NRZI signals begin at a low voltage.
- b. What signal-to-noise ratio (in dB) is needed to put a T4 carrier (274.176 Mbit/s) on a 100-MHz line?
- c. Suppose it was possible to send 8 different types of signals on a link (0,0,0), (0,0,1) (0,1,0) ... (1,1,1). How many bps can such a link achieve at 1200 baud?
- d. A modem constellation diagram has data points at (0, 1) and (0, 2). Does the modem use phase modulation or amplitude modulation?
Hint: What is the phase difference between these two points in a plane?

3. Framing

Consider the data bit sequence 0010 0110 1011 0100 1010 1001 1101 1011 1101 1111 0000 1110. In this problem, you are required to frame these bits in three different ways.

- a. Frame the above bits with byte stuffing as used in the BISYNC protocol. You need show only the body (including stuffed bytes) and the sentinel bits. DLE is 10 (decimal), STX is 2, and ETX is 3.
- b. Second, frame the bits using bit stuffing as defined by the HDLC protocol. Again, you need show only the (stuffed) data bits and the sentinel bits.
- c. Third, frame the bits using the SONET STS-1 protocol.
- d. Calculate the framing efficiency (as a percentage of real data per bit sent) of your answers to (a), (b), and (c).

4. Error Detection

- a. A CRC is constructed to generate a 4-bit checksum for an 11-bit message. The generator polynomial is $x^4 + x^3 + 1$. Encode the data bit sequence 11110010111. Now assume that bit 4 (counting from the least significant bit) in the code word is in error and show how the error is detected.
- b. The bit sequence **10110010001** corresponds to the polynomial $x^{11} + x^9 + x^8 + x^5 + 1$. Divide this polynomial by the CRC generator polynomial $x^4 + 1$ and report the remainder as a polynomial. Is the bit sequence correctly encoded with the given generator (i.e., is the remainder 0)?
- c. A block of bits with n rows and k columns uses horizontal and vertical parity bits for error detection. Suppose that exactly 16 bits are inverted due to transmission errors. Derive an expression for the probability that the error will be undetected. Assume $(n * k) > 16$.
Hint: Using basic Combinatorics, count the number of cases in which you will not be able to detect bit inversions.

5. Internet checksum

Suppose that one byte in a buffer covered by the Internet Checksum algorithm needs to be decremented (e.g. header hop count field). Give an algorithm to compute the revised checksum without re-scanning the entire buffer. Your algorithm should consider whether the byte in question is low order or high order.

6. Networking Utilities

Read the manual pages for the Unix utility `netstat` on an `eelnxxx.ews.uiuc.edu` machine. Try running the command using various options. (Not all options at the same time!). Among other things, you can use the command: `netstat -t` to display the currently active network connections (both incoming and outgoing), routing tables, and a number of network interface statistics. In particular you are required to find and report the following statistics **along** with the particular options you were required to use to obtain this information.

- a. the local and remote socket addresses (where a socket address is a host address plus a port number) for three TCP sockets in use (any status) on an `eelnx` workstation.
- b. the Ethernet address of `eelnx24` and `eelnx25`. (Hint: You needn't log onto these stations. You might have to ping them though, in order to make sure the `eelnx` machine you are on has recently seen an Ethernet packet from each of the two machines.)
- c. the number of packets sent and the number of packets received by a `eelnx` machine in a 20 second interval (report the machine name and time of day for this data collection). Use the primary network interface for this purpose. You are required to report how you determined which is the primary interface of the machine you were using. (*Hint:* Use `netstat`!).

Note: In future problem sets you will be asked to explore the Unix networking utilities `nslookup`, `ifconfig`, and `arp`.